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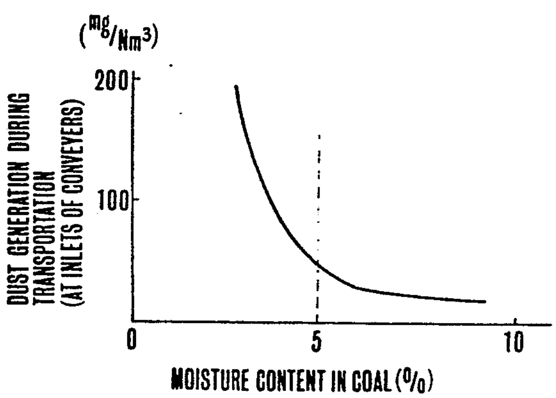
(71) Applicant: Nippon Steel Corporation,
6-3 Ote-machi 2-chome Chiyoda-ku, Tokyo 100 (JP)

(72) Inventor: Otabe, Norio Nippon Steel Corporation,
Yawata Works 1-1-1, Edamitsu Yahatahigashi-ku,
Kitakyushu-shi Fukuoka-ken (JP)
Inventor: Shimakawa, Yoshiaki Nippon Steel Corporation, Yawata Works 1-1-1, Edamitsu
Yahatahigashi-ku, Kitakyushu-shi Fukuoka-ken (JP)
Inventor: Uematsu, Hiroshi Nippon Steel Corporation,
Yawata Works 1-1-1, Edamitsu Yahatahigashi-ku,
Kitakyushu-shi Fukuoka-ken (JP)

(74) Representative: Vossius Vossius Tauchner Heunemann Rauh, Siebertstrasse 4 P.O. Box 86 07 67,
D-8000 München 86 (DE)

(54) A method for drying coking coals to be charged in a coke oven.

(57) Disclosed is a method for drying coking coals to be charged in a coke oven utilizing a heat medium which recovers the sensitive heat contained in the gas generated in the coke oven as a heat source for drying coking coals to aimed moisture. Chiefly based on the moisture of coking coals before drying, flow rate of the heat medium to the coke dryer is controlled or a hot blast generated in a separate heating system is used for the drying.



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VOSSIUS · VOSSIUS · TAUCHNER
HEUNEMANN · RAUH
PATENTANWÄLTE
SIEBERTSTR. 4, 8000 MÜNCHEN 80
TEL. (089) 47 40 75

0073498

Our Ref.: S 068 EP
Case 7692

NIPPON STEEL CORPORATION
TOKYO, JAPAN

A METHOD FOR DRYING COKING COALS TO BE CHARGED IN A COKE OVEN

The present invention relates to a method for drying coals, particularly coking coals, by using a heat medium for exchanging the sensitive heat of gas generated from coke ovens and using this heat medium containing the sensitive heat as a main heat source for the drying.

Description of the Prior Art:

In coke ovens in which coking coals are distilled to produce coke, the oven gas generating during the distillation in carburization chambers passes through ascension pipes to bend pipes communicating to dry mains and the gas is cooled in the bend pipes by a liquor spray with ammonia liquor, then the oven gas collected in the bend pipes is further cooled down to about ordinary temperatures by gas coolers. The gas generating from the coke oven is usually at a temperature ranging from 600 to 800°C, but due to the lack of efficient means for recovering the heat contained in the oven gas, or due to failure in finding appropriate applications for the recovered heat from the oven gas, no practical trials have been made for recovering the waste heat of the coke oven gas.

Meanwhile, in coke ovens combustion chambers are provided adjacent to the carbonization chambers and gaseous fuels are burnt therein for the purpose of distillation of coking coals, and only part of the waste gas generating from the combustion is recovered in heat regenerating chambers and the remainder is not utilized in the conventional arts.

The present inventors have made extensive studies and experiments for recovering the sensitive heat contained in coke oven gases from the point of energy saving and proposed a method as disclosed in Japanese Patent Application Laid-Open No. Sho 55-40736, according to which a heat-stable organic heat medium, such as alkyldiphenyl, having a high boiling point, high fluidity at low temperatures, and being usable as liquid under the ordinary pressure is supplied through heat conductive pipes arranged in the inside wall of ascension pipes of coke ovens to recover the sensitive heat of coke oven gases and utilize this recovered heat for pre-heating the combustion gas for hot blast ovens.

The method just mentioned above has been found to be very effective to recover the heat at a high recovery ratio.

Summary of the Invention:

One of the objects of the present invention is to provide methods for drying coking coals utilizing the recovered heat of coke oven gas as main heat source for drying coking coals.

According to the present invention, the sensitive heat of the coke oven gas which hitherto been dispersed wastely into cooling water is recovered by a heat medium in ascension pipes, for example, of coke ovens, and the heat thus recovered is used as a heat source for drying coking coals to be charged in coke ovens so that significant advantages can be obtained with respect to the operation and equipments of coke ovens as well as the energy saving.

The method of the present invention comprises a step of recovering the sensitive heat contained in gas generating from a coke oven by a heat exchanger using a heat medium, a step of heating the heat medium which has recovered the sensitive heat of the coke oven gas to a temperature high enough to obtain a predetermined moisture content in the coking coal after drying in case the moisture content of the coking coal before drying is higher than a predetermined value, a step of by-passing part or whole of the heat medium to a cooler or directly to the heat exchanger on the basis of the moisture content in the coking coal before drying, the predetermined moisture content in the coking coal after drying and the temperature of the heat medium which has recovered the sensitive heat of the coke oven gas in case the moisture content of the coaking coal before drying is lower than the predetermined value, a step of drying the coking coal to be charged in the coke oven with the heat medium containing the sensitive heat of the coke oven gas, and a step of maintaining the heat medium at a predetermined temperature at an inlet of the heat exchanger.

According to a modification of the present invention, the coking coal to be charged in the coke oven is dried indirectly by the heat medium containing the sensitive heat of the coke oven through the flow path of the heating medium, and when the coking coal to be charged to the coke oven contains moisture higher than a predetermined value, a hot blast generated in a separate system is introduced into the drier to directly dry the coal.

Brief Explanation of the Drawings:

Fig. 1 shows the relation between the dust generation during transportation and the moisture contents in coking coals.

Fig. 2 shows the frequency distribution of moisture contents in coking coals before drying.

Fig. 3 shows the frequency distribution of moisture contents in coking coals after drying.

Fig. 4 shows a schematic arrangement of equipments for practising the present invention.

Fig. 5 shows schematically a modification of the present invention.

Fig. 6 shows a schematic arrangement of equipments for practising the modification of the present invention.

Detailed Explanation of the Invention:

According to the present invention, the sensitive heat of the coke oven gas at about 600 to 800°C is recovered through a heat exchanger provided in the ascension pipe portion of the coke oven using an organic heat medium flowing through a flow path provided between the inner and outer mantles and the heat medium which has caught the sensitive heat of the oven gas is supplied to the coal drier as a heat source for drying.

Generally, the moisture content in the coking coal will vapourize during the distillation of the coal in the coke oven, and the heat energy required for the vapourization of moisture is about 2.5 times of the theoretical value, thus requiring a large amount of fuel. Therefore, it is most desired that the moisture content in the coking coal is decreased to almost 0% from the point of energy saving. However, from the aspect of handling of the coal, there are limitations in drying the coal in the conventional arts, because as the moisture content decreases the possibility of dust generation during the transportion and the possibility of explosion during the charging to the coke oven will remarkably increase.

According to the studies of the present inventors,as illustrated in Fig. 1, the dust generation during the transportation of coals will remain little if the moisture is not lower than about 5%, but will sharply increase if the moisture is lower than 5%. It has also been found that if the moisture content is about 5%, there is no possibility of explosion during the charging to the coke oven. Thus it has been found that the energy saving effect can be satisfactorily achieved by maintaining the moisture content in the coking coal at about 5% without providing a separate dust collecting system and an additional improvements of charging car.

Meanwhile, as shown in Fig. 2, the moisture contents in coking coals vary between 7 and 11% depending on the storing condition in storing yards as the climate changes. It has been found that the amount of heat which can be recovered from the coke oven gas is almost equal to the heat energy which can decrease the moisture content of the coal by 4%. Thus, when the moisture content is 7%, the recovery of the sensitive heat of the coke oven will be excessive. Therefore only part of the heat medium in an amount required for decreasing the moisture content 7% to 5% is supplied to the coal drier, while the remainder of the heat medium is passed through by-pass routes to join the main heat medium flow coming out of the drier. In this case, as the heat discharge in the drier is relatively small so that the temperature of the heat medium rises during the circulation. However, it is desirable that the temperature of the heat medium entering the heat exchanger is maintained constant and for this purpose a cooler for cooling the heat medium is provided between the drier and the heat exchangers in the ascension pipe portions. In this way, the desired moisture content about 5% of the coking coal to be charged in the coke oven can be obtained.

In the cases where the moisture contents of the coking coals before the charging to the coke oven are about 11%, the moisture content will be decreased to about 7% by the heat recovered by the heat medium, and it is desirable further to decrease the moisture content to about 5% by providing an additional means for heating the heat medium.

Thus, according to the present invention, the amount of the heat medium, as well as the amount of the fuel used in the coke oven, is adjusted in accordance with the variation of the moisture content of the coking coal to be charged in the coke oven, and desirably the temperature of the heat medium is controlled at the entrance of the heat exchanger. In this way, as shown in Fig. 3, the moisture content in the coking coal is maintained constantly at about 5%.

Regarding the temperature of the heat medium entering the ascension pipe:

(1) a lower temperature is desirable for maintaining a larger difference between the gas temperature of the coke oven and the temperature of the heat medium so as to recover a larger amount of heat energy;

(2) a higher temperature of the heat medium is desirable for assuring a larger amount of the heat exchange in the indirect-type coal drier by providing a larger difference between the temperature of the heat medium and the temperature of the coking coal;

(3) it is desirable to maintain the heat medium at a temperature lower than the boiling temperature of the heat medium so as to use it in a liquid state, thus saving the cost of the transportation of the heat medium and the cost of the piping arrangement; and

(4) it is desirable to maintain the heat medium at a constant temperature so as to facilitate and simplify the control of the circulation system of the heat medium.

In a preferable embodiment of the present invention, the cooler provided before the ascension pipe is operated when the temperature of the heat medium coming out from the coal drier is higher than the predetermined temperature. On the other hand, when the temperature of the heat medium is lower than the predetermined temperature, the amount of the fuel used in the heating furnace for heating the heat medium is increased so as to control the temperature of the heat medium entering the ascension pipe. Thus the temperature of the heat medium entering the ascension pipe can be controlled to a constant temperature by connecting the heat medium heating furnace the coal drier and the cooler in the circulation system.

As described hereinabove, the feature of the present invention lies in that the sensitive heat of the coke oven gas is recovered with a heat medium and this heat medium is used as the heat source for drying the coking coal.

However, there is no specific limitation regarding the structure of the heat exchanger provided in the ascension pipe. For example, the inner side of the mantle wall of the coke oven is not coated with lining and the oven gas is cooled by the heat medium directly through the mantle wall, or the mantle wall may be coated with an appropriate lining. In any way, the heat medium path is made between the inner and outer mantles of metal, or the path is made by straight or spiral piping arrangement so as to circulate the heat medium therethrough to recover the sensitive heat of the coke oven gas and increase the temperature of the heat medium.

Hereinbelow, the description will be made on the modification of the present invention where a hot blast generated in a separate heating system is used for drying the coal containing moisture more than the predetermined level.

As shown in Fig. 5, the hot blast generated in the separate system is blown into the drier to bring the coal into direct contact with the hot blast to evaporate the moisture content of the coal. According to this modification, in a multi-pipe indirect type of rotary drier incorporating a number of pipes 102 in the cylindrical body 101, the heat medium at high temperatures is passed through the pipes so as to perform an indirect heat exchange with the coal 103 moving the outside of the pipes, thus constantly evaporating a constant amount of the moisture contained in the coal and assuring a moisture content 7% of the coal. Meanwhile, in order to obtain the aimed moisture content 5%, the hot blast 105 generated in the hot blast oven 125 is blown into the drier through the front portion 106 or the rear portion 107 so as to bring the coal into direct contact therewith, thus performing the heat exchange, and the waste gas is discharged from the rear portion 107 or the front portion 106. In this case, the hot blast is maintained at a flow rate and at a temperature just enough to decrease the moisture content of the coal by 2%, but it is desirable that the flow rate as well as the temperature of the hot blast can be changed in order to desirably adjust the degree of drying of the coal.

For this purpose, moisture meter 120 is provided to measure the moisture contents and the signals thereof are sent to the fuel adjusting valve 127 of the hot blast generator to control the fuel supply. In this way, it is possible to adjust the amount of the fuel used in the hot blast generator in accordance with the variation of the moisture content in the coal and control the flow rate and temperature of the hot blast at the entrance of the drier, thus maintaining the moisture of the coal coming out from the drier constantly at about 5% as shown in Fig. 3. The numerical references 104, 108 and 109 represent respectively a joint, an entrance for the heat medium and an outlet for the heat medium.

Description of the Preferred Embodiments:

The present invention will be better understood from the following embodiments.

Example 1:

In this embodiment, the heat recovery is performed in the ascension pipe portion of the coke oven and at the same time, the heat medium heating furnace, the indirect type coal drier and the cooling means are efficiently and reasonably connected as illustrated in Fig. 4.

In Fig. 4, the system for recovering the sensitive heat of the coke oven in the ascension pipes comprises a heat exchange means connected to the heat medium circulation piping 9 at the inlet and the outlet, a heat medium circulation pump 10 in the outlet piping 9, an expansion tank 11, a heat medium storing tank 12 and a supplying pump 13 at appropriate intermediate portions of the piping 9.

Meanwhile, the system for utilizing the sensitive heat of the coke oven gas for drying the coking coal comprises a heat medium heating furnace 14 provided at the intermediate of the piping 9 of the heat recovering system, an indirect type coal drier 15 and a cooler 16 arranged after the furnace, a temperature detector 17 at the outlet of the heating furnace 14, a temperature detector 18 at the outlet of the cooler 16, a flow rate adjusting valve 20 at the intermediate of the by-pass pipe 19 of the indirect type coal drier 15, a flow rate adjusting valve 22 at the intermediate of the by-pass pipe 21 of the cooler 16, a moisture meter 24 at the coal supply hopper 23 to the coal drier 15, a coal discharge meter 25, a moisture meter 27 at a reception hopper 26 at the outlet of the drier, a calculator 28 for controlling the moisture content of the coal after the drying to 5%, a gas burner 29 in the heat medium heating furnace, a gas amount adjusting valve 30 and a gas supplying blower 31.

The heat medium normally flows in the direction shown by an arrow along the solid line in Fig. 4. The heat medium heated in the ascension pipe 8 is pressured by the circulation pump 10 to pass through the heat medium heating furnace 14 to enter the coal drier 15 where the heat medium discharges the heat to the coal. The amount of heat discharge here is almost equal to the heat, about 50,000 Kcal/ton of coal which the heat medium catches in the ascension pipe, and it is equivalent to the heat energy required for decreasing the moisture content of the coal by 4%. Therefore, when the moisture content at the entrance of the drier is 11%, the moisture content obtained at the outlet of the drier will be 7%. In order to achieve the desired final moisture content of 5%, the heat medium is heated from 200°C to 220°C in the heating furnace. This can be performed by detecting the coal discharge amount by the measure 25, detecting the moisture content by the moisture meter 24 and then by the moisture meter 27, processing the signals thus obtained by the calculator to set the temperature of the heat medium at the entrance of the drier, and controlling the combustion gas flow rate by the flow rate valve 31 on the basis of the temperature signal so as to maintain the set temperature of the heat medium in the heating furnace.

Meanwhile, when the moisture content at the entrance of the drier is 7%, the moisture content at the outlet is 3%. This means an excessively dried state, very likely to cause troubles such as dust generation. Therefore, in order to dry the coal to the aimed moisture content 5%, the amount of the heat medium passing through the by-pass pipe 19 and entering the drier is decreased for this purpose, the amount of coal discharge is detected by the discharge meter 25, the moisture content of the coal is detected by the moisture meter 24 and then by the meter 27, and the detection signals thus obtained are processed by the calculator to control the flow rate of the heat medium passing through the by-pass pipe 19 by the flow rate adjusting valve 20.

For prevention of the degradation of the heat medium and the idle operation of the circulation pump, the heat medium is used in a liquid state. For this purpose, if the boiling point of the heat medium is 280°C, it is desirable to use the medium at about 200°C or lower so as to provide a margine of about 80°C.

In this case, the temperature of the heat medium is set at 160°C at the entrance of the ascension pipe and set at 200°C at the outlet of the pipe. If the moisture content of the coal at the entrance of the coal drier continues to be at 7% or near, the amount of the heat medium passing throgh the by-pass pipe 19 increases and the temperature of the heat medium at the entrance of the ascension pipe increases to a temperature beyond the boiling point of the heat medium in the course of circulation. In order to prevent this excessive temperature increase, the cooler 16 is provided to maintain the heat medium at the entrance of the ascension pipe at a constant temperature. This can be done by detecting the temperature at the outlet of the cooler by the detector 18 to control the amount of the flow rate of the heat medium passing through the by-pass pipe 21 to maintain a constant temperature. There is no specific limitations on the cooling method.

The working data and results of the above embodiment are shown in Table 1.

Table 1

Number of Ascension Pipes	70
Heat Energy Recovered in Ascension Pipes	43000 Kcal/H
Temperature of Heat Medium	160 → 200°C
Circulation Rate of Heat Medium	168 m^3/H
Amount of Coal Treated	60 T/H
Moisture Content in Coal	9 → 5 %
Moisture Content after Drying	4 %
Energy Saved	60000 Kcal/ton of coal (3600000 Kcal/H)
Coke Yield Improvement	1 - 2 %
Consumption of Combustion Gas in Coke Oven (Moisture Content 9%)	550 Nm^3/ton of coal (33000 Nm^3/H)
Consumption of Combustion Gas in Coke Oven (Moisture Content 5%)	490 Nm^3/ton of coal (29400 Nm^3/H)
Difference (Mixed Gas decreased)	60 Nm^3/ton of coal (3600 Nm^3/H)

H = hour

Example 2:

This Example illustrates the modification of the present invention in which the sensitive heat of the coke oven gas is recovered in the ascension pipe of the oven and at the same time a hot blast generator is efficiently and reasonably connected to the indirect type coal drier.

In Fig. 6, the sensitive heat recovering system in this embodiment is same as that in the first embodiment. Thus the system comprises a heat exchanging means connected to the heat medium circulation piping 111 at the inlet and the outlet, a heat medium circulation pump 112 in the outlet piping 111, an expansion tank 113 a heat medium storing tank 114 and a supplying pump 115 at appropriate intermediate portions of the piping 111. Meanwhile, the system for utilizing the sensitive heat of the coal oven gas in this embodiment comprises a multi-pipe type coal drier 116 provided in the path of the piping 111 of the heat recovering system, a flow rate adjusting valve 118 in the path of the by-pass pipe 117 of the coal drier, a coal supply hopper 119 to the coal drier, a moisture content meter 120, a coal discharge meter 121 provided in the hopper, a reception hopper 122 at the outlet of the drier, a moisture meter 123, a calculator 124 for controlling the moisture content of the coal after the drying to 5%, provided in the reception hopper, a hot blast generator 125, a gas burner 126, a gas amount adjusting valve 127 and a gas supplying blower 128, provided in the hot blast generator 125.

The heat medium normally flows in the direction shown by the arrow along the solid line as shown in Fig. 6. The heat medium heated in the ascension pipe 110 is pressurized by the circulation pump 112 and enters the coal drier where it discharges the heat to the coal. The heat energy discharged here is almost equal to the heat energy of about 50,000 Kcal/ton of coal which the heat medium catches in the ascension pipe. This energy is equivalent to decrease the moisture content in the coal by 4%. Thus when the moisture content at the entrance of the drier is 11%, the moisture content at the outlet of the drier is 7%. In order to dry the coal to the aimed moisture content of 5%, the hot blast of 500°C is generated in the hot blast generator and supplied to the drier at a flow rate of 100 Nm^3/ton of coal.

For this purpose, the amount of coal discharge is detected by the discharge meter 121 and the moisture contents of the coal are detected by the moisture meters 120 and 123 and then their signals are processed by the calculator to set the temperature of the hot blast at the entrance of the drier. In the hot blast generator the temperature signal is received to control the flow rate of the combustion gas by the flow rate adjusting valve 127.

Meanwhile, when the moisture content at the entrance of the drier is 7%, the moisture content at the outlet is 3%, which indicates an excessively dried state, very likely to cause troubles such as dust generation etc. Therefore, in order to dry the coal to the aimed moisture content of 5%, the amount of the heat medium passing through the by-pass pipe 117 is increased while the amount of the heat medium entering the drier is decreased. For this purpose, the amount of coal to be discharged is detected by the discharge meter 121, the moisture contents in the coal are detected by the moisture meters 120 and 123 and their signals are processed by the calculator to control the flow rate of the heat medium passing through the by-pass pipe 117 by the flow rate adjusting valve 118.

The working data and results of this embodiment are same as shown in Table 1.

As clearly understood from the foregoing descriptions, the present invention can efficiently recover the sensitive heat from the coke oven gas and at the same time can advantageously utilize the recovered heat as a heat source for drying the coking coals to be charged in the coke ovens, thus remarkably reducing the amount of fuel consumed in the coke ovens and remarkably improving the coke production yield. Concludingly, the present invention is very advantageous from the aspect of energy saving.

What we claim :

1. A method for drying coking coals to be charged in a coke oven, which comprises:

a step of recovering sensitive heat of gas generated in the coke oven with a heat exchanger using a heat medium;

a step of heating the heat medium to a temperature equivalent to obtain an aimed moisture in the coking coal after drying;

a step of drying the coking coal with the heat medium; and

a step of controlling the temperature of the heat medium to be introduced to the heat exchanger to an aimed temperature at the entrance of the heat exchanger.

2. A method for drying coking coals to be charged in a coke oven, which comprises:

a step of recovering sensitive heat of gas generated in the coke oven with heat exchanger using a heat medium;

a step of by-passing part of the heat medium on the basis of moisture of the coking coal before drying;

an aimed moisture of the coking coal after drying, and the temperature of the heat medium;

a step of drying the coking coal with the remainder of the heat medium; and

a step of controlling the temperature of the heat medium to be introduced to the heat exchanger to an aimed temperature at the entrance of the heat exchanger.

3. A method according to claim 2, which further comprises a step of cooling the by-passed part of the heat medium.

4. A method for drying coking coals to be charged in a coke oven, which comprises:

a step of recovering sensitive heat of gas generated in the coke oven with a heat exchanger using a heat medium; and

a step of supplying the heat medium as a main heating source to a coal drier to dry the coking coal indirectly through a heat medium flow path.

5. A method according to claim 4, which further comprises a step of introducing a hot blast generated in a separate system to the coal drier to directly dry the coal when the moisture of the coking coal to be charged in the coal drier.

6. A method according to claim 5, which further comprises a step of controlling at least one of the amount and the temperature of the hot blast to be introduced to the drier.

7. A method for drying coking coals to be charged in a coke oven, which comprises:

a step of recovering sensitive heat of gas generated in the coke oven with a heat exchanger using a heat medium;

a step of heating the heat medium to a temperature equivalent to obtain aimed moisture in the coking coal after drying when the moisture of the coking coal before drying is higher than a predetermined moisture;

a step of by-passing part or whole of the heat medium on the basis of moisture of the coking coal before drying, an aimed moisture of the coking coal after drying and the temperature of the heat medium when the moisture of the coking coal before drying is lower than the predetermined moisture;

a step of drying the coking coal with the heat medium; and

a step of controlling the temperature of the heat medium to be introduced to the heat exchanger to an aimed temperature at the entrance of the heat exchanger, all of the steps being connected through a heat medium flowing path.

8. A method according to claim 7, in which the part or whole of the heat medium is by-passed to a cooler.

9. A method according to claim 7, in which the part or whole of the heat medium is by-passed to a heating furnace.

FIG.1

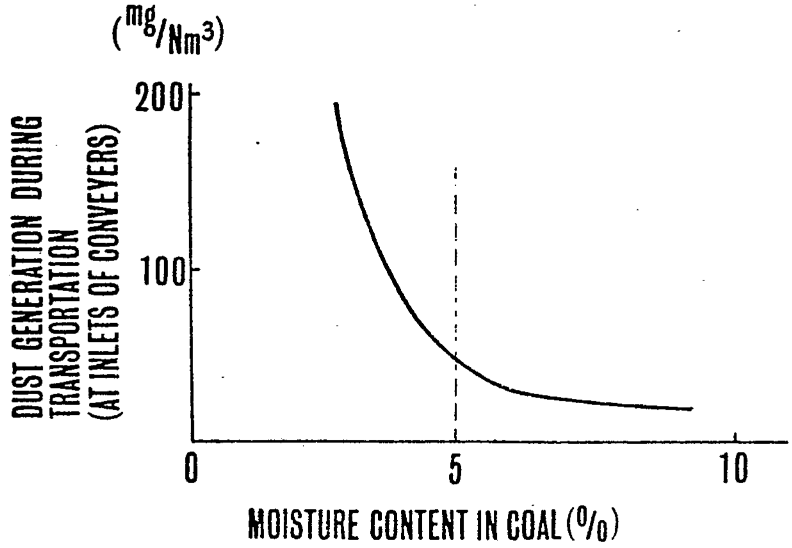
(mg/Nm3)
200
100
DUST GENERATION DURING TRANSPORTATION (AT INLETS OF CONVEYERS)
0
5
10
MOISTURE CONTENT IN COAL (%)

FIG.4

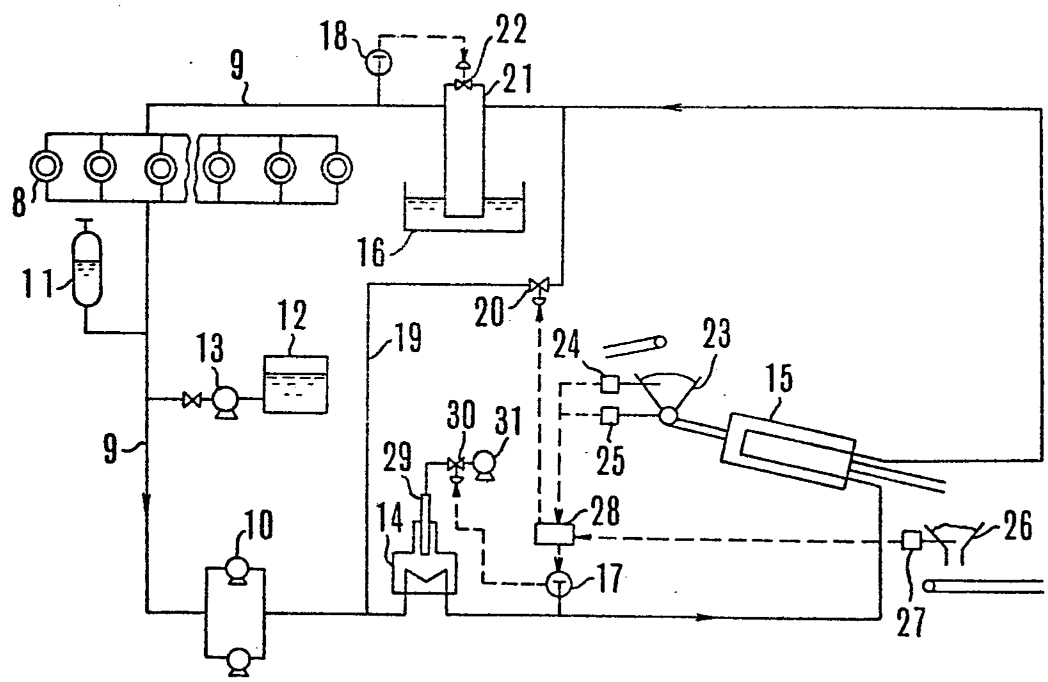
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FIG.2

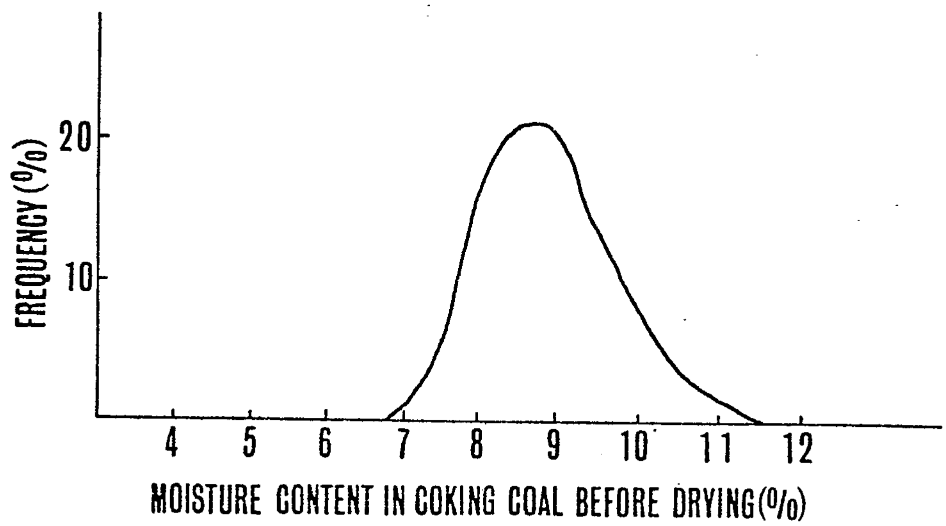
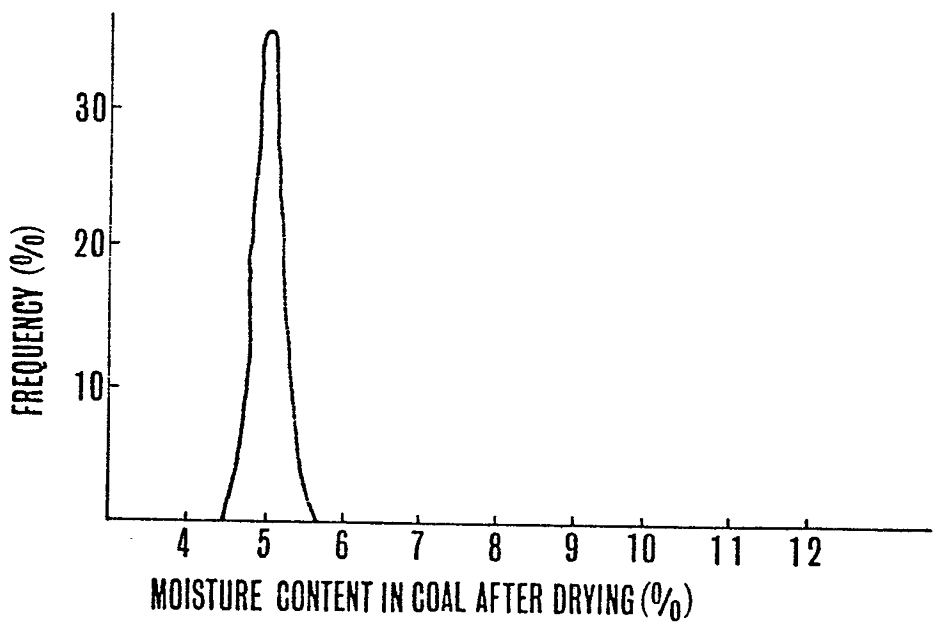

FREQUENCY (%)
20
10
4
5
6
7
8
9
10
11
12
MOISTURE CONTENT IN COKING COAL BEFORE DRYING(%)

FIG.3


FREQUENCY (%)
30
20
10
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5
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11
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MOISTURE CONTENT IN COAL AFTER DRYING (%)

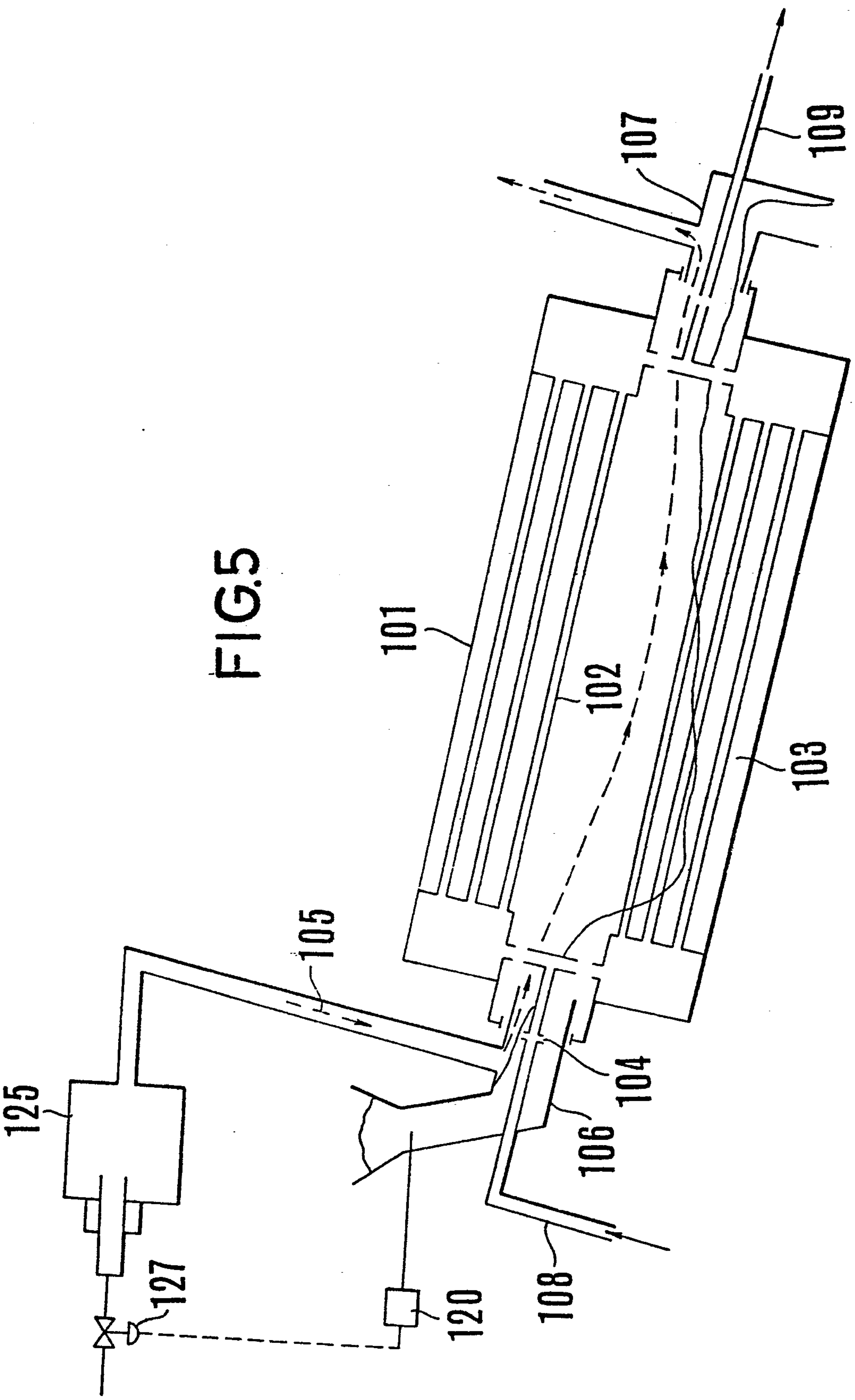
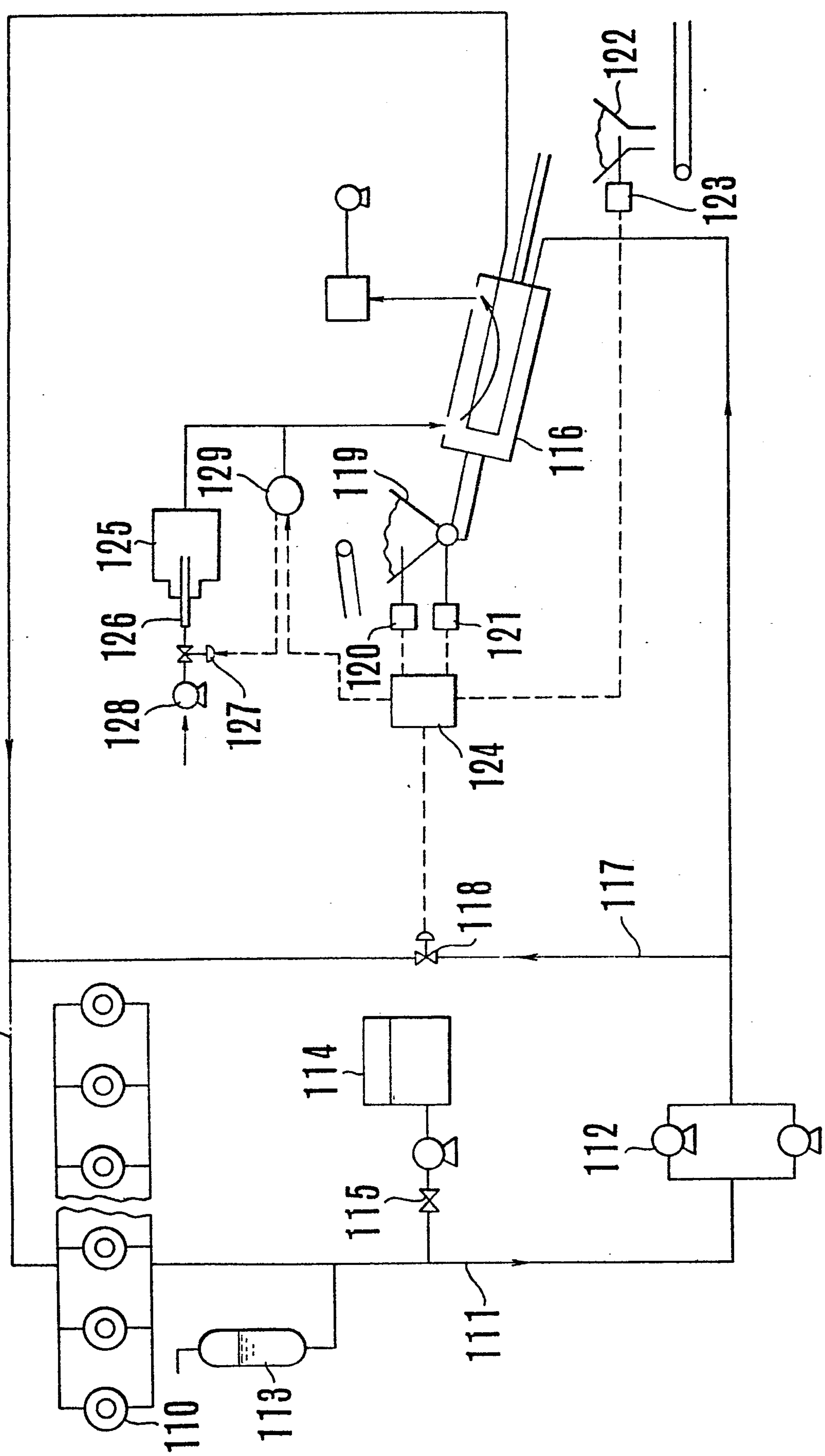


FIG.5

FIG.6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